

INDEX

absorption coefficient, 72
 absorption spectrum, 23–6
 Acker, S., 186
 action spectrum, 77–8
 adenosine diphosphate (ADP), 231
 structure, 15
 adenosine triphosphate (ATP), 9, 12, 231
 electron-proton stoichiometry in formation of, 248–50
 firefly assay, 246, 274
 free energy of hydrolysis, 249–50
 structure, 15
 allophycocyanin, 126
 allophycocyanin B, 126
 δ-aminolevulinic acid, 32, 108
 structure, 32
 Anderson, J. M., 111
 antenna (light harvesting), 27–8
 of green plants, 112–14, 118, 122–6
 physiological regulation, 106–8
 puddle and lake models, 30–1, 104
 tripartite organization in plants, 113, 115, 123
 varieties in bacteria, 105–6, 108–9
 Aparicio, P. J., 209
 Armond, P., 81
 Arnold, W., 28–30, 246
 Arnon, D. I., 210, 258
 Arntzen, C. J., 80, 81, 117
 ATPase, *see* coupling factor
 Austin, L. A., 151, 155

B850, 108–9, 152
 B860, 108–9
 B875, 108–9
 bacteriochlorophyll *a*
 absorption *in vivo* vs. *in vitro*, 149–52
 absorption maxima, 38
 absorption spectra, 147
 biosynthesis, 32
 structure, 14

bacteriochlorophyll *b*
 absorption maxima, 38
 biosynthesis, 32
 bacteriochlorophyll *c*, 127
 absorption maxima, 38
 bacteriopheophytin
 absorption band shifts, 170
 in reaction centers, 154
 bacteriorhodopsin, 129
 and proton transfer, 129–30
 Barber, J., 122
 Bassham, J. A., 257
 Beer's Law, 72
 Bendall, F., 56
 Bengis, C., 113–14, 186
 Benson, A. A., 258
 Blinks, L. R., 53, 54
 Boardman, N. K., 111
 Bohr, N., 21–2
 Boltzmann constant, 42
 Boltzmann factor, 42, 247
 Bonaventura, C., 120
 bundle sheath cell, 260
 Butler, W. L., 123–5

C550, 187, 189
 Calvin, M., 256–8
 Calvin cycle, 256–9
 carbonylcyanide *m*-chlorophenylhydrazone (CCCP), 244
 Cario, G., 49
 β-carotene, structure, 35
 carotenoids
 absorption band shifts, 241–6
 absorption spectra, 39
 as antenna pigments, 36
 protective action, 34–6
 Chain, R. K., 210
 chemical coupling hypothesis, 232–4
 chemiosmotic hypothesis, 234–5, 238
 chirality, 135

- Chlamydomonas*, 208
Chlorella, 28–9, 51, 54–5
Chlorobium limicola, 127
 cell structure, 85
 chlorophyll
 absorption spectrum of dimer, 149–50
 biosynthesis, 31–3
 dimer formation, 148–9
 spectroscopy, 146–50
 transition moments, *see transition moments, chlorophyll*
 chlorophyll *a*
 absorption maxima, 38
 absorption spectrum, 147
 biosynthesis, 32
 structure, 14
 chlorophyll *b*, 111–15
 absorption maxima, 38
 biosynthesis, 32
 structure, 14
 chlorophyll *c*, 113, 125–6
 chloroplast, 79
 core 1, core 2, 113
 DNA, 116
 fraction I, fraction 2, 113–14
 fraction I, fraction II, 112
 structure, 80, 86, 116
“*Chloropseudomonas ethylica*,” 127
 chromatic transients, 54
Chromatium vinosum, cell structure, 82
 chromatophore, 81
 circular dichroism, 135–8
 of B850, 151
 of bacteriochlorophyll *a*, 150
 of chloroplast fraction I, 153, 157
 of LHa/b, 153
 of reaction centers, 152–3, 155–7
 Cohen-Bazire, G., 106
 conformation coupling hypothesis, 232, 250–1, 253
 Conti, S. F., 82, 85, 86
 coupling, 232
 high-energy intermediate, 232
 hypotheses, 232–5
 coupling factor, 115, 248–54
 conformational changes of, 253
 protein subunits, 253
 Crofts, A. R., 222, 242
 cyanobacteria, 13
 cytochrome
 as electron donor, 90–1, 174–5
 binding of heme, 273
 biosynthesis, 32
 c types in bacteria, 218–19
 cytochrome *b* of bacteria, 213, 218, 220–1
 cytochrome *c*
 as electron donor, 219
 in bacteria, redox potentials, 219
 cytochrome *c₂*, 218–19, 221
 cytochrome Cyt 559, 190
 cytochrome *f*, 208–9
 Davidov, A. S., 135
 delayed fluorescence, 62, 246–8
 diatom, 125–6
 dichlorophenol indophenol (DCPIP), 212
 dichlorophenyl dimethylurea (DCMU), 187
 dinoflagellate, 125–6
 doublet state, 60
 Doudoroff, M., 11
 Dutton, H. J., 49
 Dutton, P. L., 220, 222
 Duysens, L. N. M., 53, 56–8, 88, 267
 Einstein, A., 21
 einstein, unit, 67
 electric dipole, 19
 electrochromic band shift, 271
 electromagnetic wave, 19–20
 energy density of, 132
 electron acceptor, 27–8
 electron capacity measurement, 171–2
 intermediate, in bacteria, 168, 176–80
 of photosystem I, redox potentials and ESR parameters, 184
 of photosystem 2, redox potentials, 188
 primary, in bacteria, 168; ESR spectrum of, 174
 redox potential, in bacteria, 173
 electron-nuclear double resonance (ENDOR), 61, 145–6
 electron orbitals, 63–6
 electron paramagnetic resonance (EPR), 61
 electron spin, 59–61, 267
 electron spin resonance (ESR), 61
 spectra of triplet states, 146
 electron transfer
 cyclic and noncyclic, 11, 125
 cyclic, around photosystem I, 204, 210
 pathways in green plants, 204–13
 pathways in green sulfur bacteria, 224–5
 pathways in purple bacteria, 214, 222–4
 secondary, in reaction centers, 168–70
 electron tunneling, 219, 272
 electronic states, ground and excited, 23
 Emerson, R., 28–9, 51, 54–5
 energy transfer, 25–7, 39–43
 governing factors, 39–40
 energy trapping, 41–9
 and fluorescence, 45–6
 Engelmann, T. W., 49
 enhancement effect, 54–5
 N-ethylmaleimide, 253
 exciton interaction, 135–8
 in antenna, 152–7

Index

279

- extinction coefficient of chlorophyll and of cytochrome, 73
- Fager, E. W., 258
- Feher, G., 175, 215
- Fenna, R. E., 128
- ferredoxin-NADP reductase, 210, 224
- ferredoxins, 182, 210, 224
structures, 182–3
see also iron-sulfur centers
- fluorescence, 23
components in chloroplasts, 123–5
lifetime and yield, 99–101
of bacterial reaction centers, 94
of chloroplasts, 119–21
of chromatophores, 103–4
relation to absorption, 98–9
relation to photochemistry, 99–105
spectra, 23–6
states I and II in chloroplasts, 121
- formaldehyde, 4
- Franck, J., 49
- Franck-Condon principle, 266
- French, C. S., 55
- Fuller, R. C., 85
- Gaffron, H., 9–12, 211, 258
- Gantt, E., 86
- Good, N., 121
- gramicidin, 244
- green plants, antenna, 48
- green sulfur bacteria
antenna, 48, 127–9
bacteriochlorophyll *a*-protein, 128–9
cytochromes, 224–5
electron acceptors, 96–7, 180, 224
electron donor, *see* P840
- iron-sulfur centers, 224
- NAD reduction, 224
- reaction centers, 96–7
- substrates for, 224–5
- Halobacterium halobium*, 129–30, 252, 266
- Hatch-Slack-Kortschak (HSK) cycle, 260–1
- Haxo, F. T., 53
- Hill, R., 8–9, 56
- Hill reaction, 9
- Holt, S. C., 85
- hydrogenase, 211, 264
- hydroxylamine, 189–90
- image reconstruction, 271
- index of refraction, 19
- internal conversion, 269
- intersystem crossing, 269
- iron, in bacterial reaction centers, 174
- iron-sulfur centers, 182–3, 214
as electron acceptors, 180
Rieske center, 209
structures, 183
- Izawa, S., 121
- Jackson, J. B., 242
- Jagendorf, A. T., 237
- Joliot, P., 194
- Kasha, M., 135
- Katz, J. J., 148
- Kok, B., 167, 195
- laser, 98
- lauryl dimethyl amine oxide, 269
- Levine, R. P., 208
- LHa/b, 112–14, 118, 122–6
- light
absorption, 23
frequency, 19
polarized, *see* polarized light
units, 71
wavelength, 19
- linear dichroism, 139
- dichroic ratios, 142–4
methods for orientation, 139–40
of bacterial reaction centers, 159–61
of chloroplasts, 158
of photosynthetic bacteria, 159–61
- Lippman, F., 9
- McCarty, R. E., 252
- magnesium
and chloroplast fluorescence, 121
and thylakoid stacking, 119, 121–2
- Malkin, R., 209
- manganese
as electron donor to photosystem 2, 190
role in oxygen evolution, 201
- Manning, W. M., 49
- Mathis, P., 186
- Matthews, B. W., 128
- Mauzerall, D. C., 31
- membrane
cytoplasmic, 79–83
intracytoplasmic, 79–83
topology, 81
- membrane Bohr effect, 216, 221
- menaquinone, 171, 225
- mesophyll cell, 260
- Meyerhof, O., 9
- microwave spectroscopy, 60, 145
- Mitchell, P., 234
- Mössbauer spectroscopy, 272
- Myers, J., 55, 120
- Nelson, N., 113–14, 186
- Nernst equation, 69

280 *Index*

- nicotinamide-adenine dinucleotide (NAD),
 12, 214, 224
 structure, 16
 nicotinamide-adenine dinucleotide phosphate (NADP), 12, 210
 structure, 16
 nigericin, 241
 nuclear magnetic resonance (NMR), 61
- Okamura, M. Y., 175, 215
 Olson, J. M., 31, 128
 Olson, R. A., 158
 optically detected magnetic resonance, 63
 oxidation and reduction, 6–8
 as hydrogen transfer, 7
 energy of, 67–70
 potential, *see* redox potential
 oxygen
 as poison, 34
 singlet state, 34, 36
 oxygen evolution, photosynthetic,
 193–203
 activation requirement, 194
 cycle of S states, 195–8
 four quantum summation, 193–4
 hypothetical reaction scheme, 201
 proton release attending, 199–200
 ozone, atmospheric, 37
- P680, 167
 absorbance changes, 182
 ESR parameters, 182
 redox potential, 182
- P700, 112
 absorbance changes, 155, 182
 ESR parameters, 182
 redox potential, 182
- P840, 96, 224
 absorbance changes, 169
 ESR parameters, 169
 redox potential, 169
- P870, 88
 absorbance changes, 169
 ESR parameters, 169
 extinction coefficient, 167
 redox potential, 167, 169
- P980
 absorbance changes, 169
 ESR parameters, 169
 redox potential, 169
- Parson, W. W., 91
 Peters, G. A., 83
 phenazinium methyl sulfate (PMS), 212
 Philipson, K. D., 155
 phospho-enol pyruvic acid, 261
 PEP carboxylase, 260
 phosphorescence, 62
- photoelectron microscopy, 118
 photoselection, 140–1
 and energy transfer, 141
 and rotational mobility, 141–2, 162
 dichroic ratios, 144–5
 polarization factor, 145
- photosynthesis
 action spectra, 53
 bacterial, 4–5
 energy efficiency, 254
 evolution, 31–7
 overall equation, 3
 quantum efficiency, 51–3
 photosynthetic unit, 29–30
- photosystem 1, 13
 electron acceptors, 181–5
 electron donor, 181; *see also* P700
- photosystem 2, 13
 electron acceptors, 181, 185–6, 188; *see also*
 quinone; plastoquinone
 electron donor, 181; *see also* P680
 electron transfer kinetics, 187–90
 external electron donors, 189
 fluorescence, 187–8
 secondary electron donors, 187–90
- phototaxis, 37
- phycobilins
 absorption maxima, 39
 as antenna, 38, 48–9
- phycobilisome, 48, 126
- phycocyanin
 absorption maxima, 39, 126
 structure, 35
- phycoerythrin, absorption maxima, 39,
 126
- $\pi\pi^*$ transition, 65
- π state, 65
- Planck, M., 21
- plasmadesmata, 260
- plastocyanin, 208–9
- plastoquinone
 in photosystem 2, 181, 204–8
 structure, 17
- polarized light, 132–5
 circularly polarized light, 133–5
 plane polarized light, 133
- polyacrylamide gel electrophoresis, 269
- Porphyridium cruentum*, 56–7
 cell structure, 86
- Poynting vector, 270
- Priestley, J., 3
- Prochloron*, 13, 126
- Prosthecochloris aestuarii*, 127
- proton binding and redox potential, 69–70
- proton transport
 and ATP formation/hydrolysis, 212–13,
 236–7
 and cyclic electron transfer, 210

Index

281

- in chloroplasts, 205
- in photosynthetic bacteria, 214, 222–5
- protonmotive force, 235
 - components of, 235–6, 243
- pyruvate carboxylation pathway, *see* Hatch-Slack-Kortschak cycle
- quantum distribution in chloroplasts, 119–25
- quantum efficiency measurement, 75–7
- quantum energy, 67
- quantum theory, 22
- quinones
 - as electron acceptors, 91, 181
 - in reaction centers, 181
 - primary and secondary in bacteria, 168, 171, 215–18
 - reduced forms, 17
 - structures, 17
- Racker, E., 250, 258
- reaction centers, 27–8
 - energetics, 70–1
 - of photosystem 1, structural model, 186
- reaction centers, bacterial
 - absorbance changes, 94–6, 154, 156
 - absorption spectrum, 94–5
 - bacteriofophytin in, 92–3
 - chlorophylls as special pairs, 145, 153–4, 156
 - composition, 92–3
 - electron donors and acceptors, 168; *see also* P870, P980
 - isolation of, 88–90
 - of green sulfur bacteria, 96, 181
 - of *Rhodopseudomonas viridis*, 157
 - photochemical efficiency, 101–2
 - photoproducts, 92–3
 - polypeptides of, 92–3
 - structural model, 175–6
 - triplet states in, 176–80
 - variety, 96
- red drop effect, 54
- redox potential, 69–70
- reductive pentose cycle, *see* Calvin cycle
- Remsen, C. C., 84
- Rhodopseudomonas sphaeroides*
 - absorption spectrum, 47
 - antenna, 46–7
 - cell structure, 83
- ribulose diphosphate carboxylase, 115, 257
 - as oxygenase, 259
- Rieske center, *see* iron-sulfur centers
- Ryrie, I. J., 253
- Sato, V. L., 155
- Sauer, K., 148, 150, 151, 155, 186
- Searle, G. F. W., 122
- singlet state, 60
- Sistrom, W. R., 92
- solar energy conversion, 264–5
- Spector, M., 202
- spheroplast, 80
- spillover, 111, 124
- Staehelin, A., 117
- Stanier, R. Y., 11, 106
- Stark effect, 244
- Stoeckenius, W., 129
- Stokes shift, 24
- Stoll, A., 4
- Strehler, B. L., 246
- superoxide radical, 211
- Thiocapsa violacea*, cell structure, 84
- Thornber, J. P., 112–13
- thylakoid, 79–81
 - freeze-fracture image, 116–18
 - grana, 79–80
 - membrane directionality, 118–19
 - proton transfer, 119
 - stacking, 119, 121–2
 - stroma, 79–80
- Tinoco, I., 135
- transition moments, 132
 - in chlorophyll, 139, 147
 - of dimer, 135–8
- transition probability, 22
- triplet state, 60–3
 - reactivity of, 61–2
- ubiquinone, structure, 17
- uncouplers, 232
 - amines as, 238–41
- Uribe, E., 237
- valinomycin, 242
- van Best, J. A., 186
- van Niel, C. B., 4–13
- Vermeglio, A., 215
- Vishniac, W., 258
- Warburg, O., 51–3
- water splitting, 266
- wave function, 22
- wave number, 24, 67
- Willstätter, R., 4
- Winget, G. D., 202
- Witt, H. T., 167
- Wraight, C. A., 215–16
- Z scheme, 13, 56–7, 204